The Genesis and Early Days of XMM

and the Importance of the Science Working Team (1989 – 2001)

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Status of X-ray Astronomy 1970's – early 1980s

- Late 1970's ~1000 sources (prior to Einstein Obs.) – proportional counter energy resolution (sources 'soft' / 'hard', overall kT)
- Bragg crystal Spectroscopy using rocket experiments only prior to 1978 (Columbia, Leicester, MSSL):
  upper limits on bright Galactic binaries, e.g. Sco X-1, Cyg X-1, A0620-00
  positive result on Puppis SNR, optically thin: Zarnecki & Culhane 1977, MNRAS 178, 1977, 57
  Einstein FPCS results on 41 sources, including positive results on SNR and clusters (see archive in Lum, Canizares et al. 1992, ApJS 78, 423)

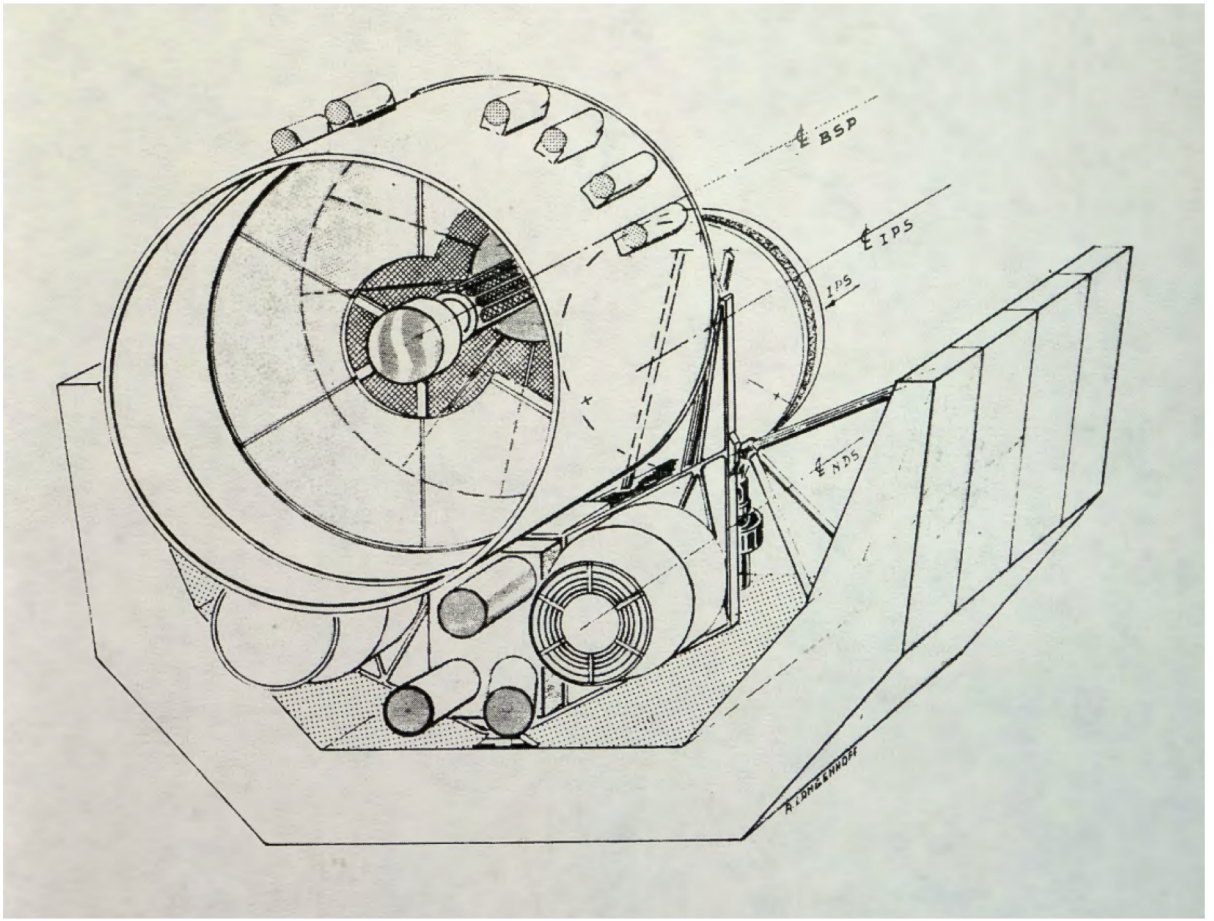
Missions prior to 1985

Mission	Date	log(S)	E-Range	<Energy>	Res.^{n}	A(eff)	Mirrors
		mCrab	keV		E/ δE	cm^2	
UHURU	1969	0	2-10	7	3	200	
HEAO-1	1977	-1	0.1 - 0.3	3	2	200	
			2 – 60	7	7	1000	
			20-1000	50	5	200	
HEAO-2	1978	-3	0.1 – 0.3	1	100-1000	0.21	Ni on fused quartz [+ OGS, FPCS]
			0.5 – 4	2	2	100	IPC
EXOSAT	1982	-2	0.04 – 2	1	2	15	CFRP
			1 – 50	7	5	700	
ROSAT	1987	-3	0.1 – 3	1	3	300	Au on zerodur

European X-ray Spectroscopy and Polarimetry on Spacelab
EXSPOS study – mid 1970's

Candidate for Single Spacelab pallet –
Multiple flights, modular instruments
Selected for Phase A Study
Several aspects later used for XMM

Consortium members involved in XMM
(Spacelab flew 22 times)



Free-standing spherically curved crystal panels for individual emission lines
e.g. Fe XXV/XXVI Si XIII/XIV, S XV/XVI
Nested paraboloid mirrors, <2keV
Transmission Gratings, Reflection Gratings
Free-standing non-dispersive detectors (GSPC, PC)
Optical / UV monitors
Modular approach – multiple flights

No CCDs (not yet developed for X-rays)

1976 A European X-Ray Spectroscopy and Polarimetry Payload for Spacelab", R. D. Andresen, A. Brinkman, K. Beuermann, J. L. Culhane, R. E. Griffiths, V. Manno, R. Rocchia and G. Whitcomb, Space Science Instrumentation, 2, 325, 337.
See also Schnopper et al. Spherical Crystal Cosmic X-ray Spectrometer, 1981

Advent of CCD's for X-ray Imaging / Spectroscopy

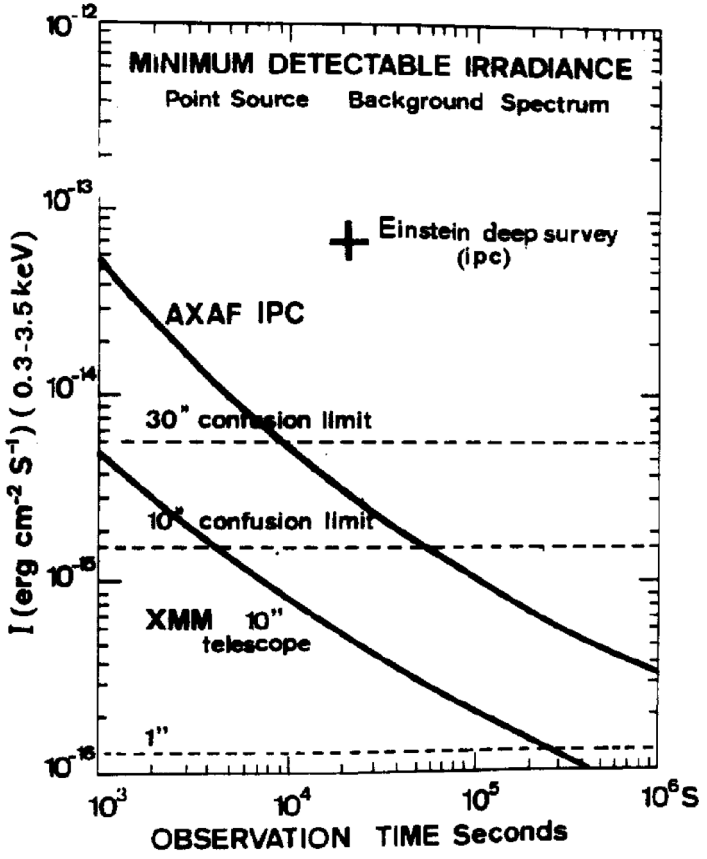
- 1969 Boyle & Smith (Bell Labs.) – bucket-brigade optical device (linear array)
- Early 1970's : Fairchild, RCA, Westinghouse, TI, GEC(UK), Thompson (France), Philips (Germany)
- WF/PC proposal for HST using TI 3-phase – Westphal et al.
- Late 1970's: Application to single-photon X-ray imaging / spectroscopy.

  CfA-HEAD, using Fairchild, RCA, Westinghouse (deep depletion), GEC

  see Griffiths et al., 1981, SPIE 290, 62
- TI 3-phase also tested for X-ray imaging (JPL - Janesick et al.) --→ AXAF
- Clear potential for AXAF and ESA mission when scaled up – ESA support from 1988

The Lyngby Workshop – June 1985

- Following UHURU, Copernicus, OSO-7, OSO-8, Ariel V, EXOSAT, Ginga, ANS, SAS-3, HEAO-1, Einstein Obs. (< 2keV, IPC)
- Widely recognized need for X-ray spectroscopy
- High throughput X-ray spectroscopy mission* proposed to ESA in 1982
- In response, Lyngby workshop (DTU) organized by ESA/ESTEC (Taylor, Peacock)
- Candidate for Second Cornerstone Mission
- ----> The High-Throughput X-ray Spectroscopy Mission
- Nested X-ray telescopes (set of 20 + set of 7) CFRP
- Reflection gratings
- CCD cameras



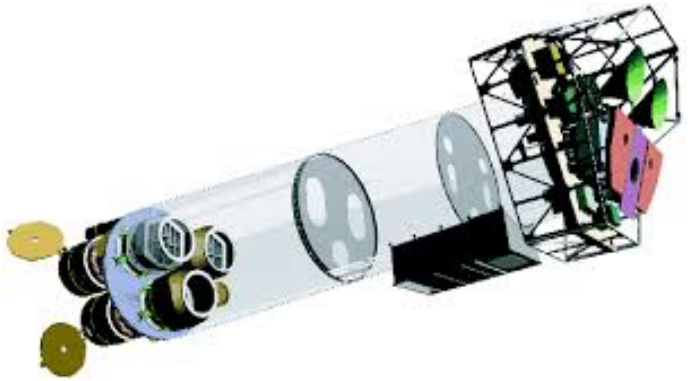
- *XMM: A Long-Lived Orbiting X-Ray Multi-Mirror Observatory,
  J. Bleeker, A. Brinkman, J. Culhane , L. Koch-Miramond, K. Pounds,
  H. Schnopper, E. Silver, G. Spada, B. Taylor, J. Trumper and N. J. Westergaard,
  Physica Scripta. Vol. T7, 224-234, 1984

Candidates for ESA ‘s Horizon 2000 (AP)

- Physics of the Sun/Earth system (SOHO/Cluster)
- The hot and energetic Universe (XMM-Newton, INTEGRAL)
- The molecular and dusty universe (Herschel)
- Primordial material in the solar system (Rosetta)
- Galactic dynamics (Hipparcos/Gaia)
- European landers (Huygens/Philae)
- The oldest light (Planck)
- Planetary Science in Europe (MarsExpress, VenusExpress)
-

The XMM ‘AO’

- Following Definition Study, XMM Selected as ESA Horizon 2000 second Cornerstone mission
- Major Differences from a NASA AO
- Instruments were largely pre-selected, collaborations organized in advance
  - EPIC – UK (M.Turner), Germany, Italy, France
  - RGS – Netherlands (A.Brinkman), USA
  - OM – UK (K.Mason), Italy, Belgium
- Instruments funded separately by national science agencies, not ESA
- Some competing instrument proposals were not selected
  - E.g. Alternative Gratings
  - STJ Verhoeve P, Rando N, Peacock, A; Appl Phys Lett 72:3359–3361
  - Doubly Curved Bragg Crystal Spectrometer (NSI, DTU, Lyngby – Byrnak, Schnopper et al.)
  - Polarimeter
- Five Mission Scientists also selected (2 from USA) and Telescope Scientist
  - Bergeron, Bleeker, Pallavicini, Griffiths, Mushotzky, Aschenbach



XMM Science Working Team 1989 - 2001

- Instrument PI's, Telescope Scientist, Mission Scientists
- Quarterly Meetings – reviews of all aspects of mission

Change from CFRP → Electroformed Nickel

- Mirrors were originally Carbon Fiber Reinforced Epoxy, CFRP**

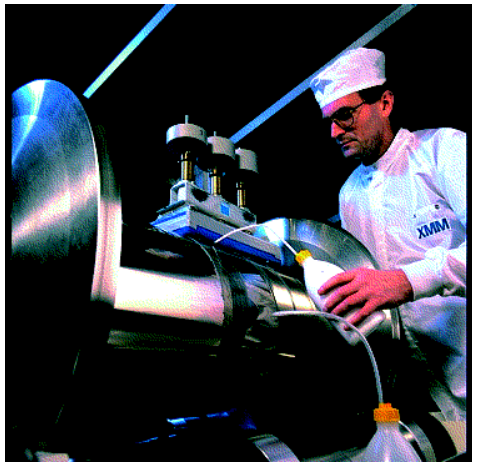
  Following EXOSAT (Piet de Korte, Utrecht) App. Optics., 1988, 27, 1440
- Mirrors on Critical Path, given early start
- XMM Contract with Carl Zeiss, Germany
- Found to exhibit warping on outgassing in vacuum testing
  - Did not meet spec. – and unknown degradation long-term
- Projected performance in orbit was unacceptable
- Inertia to change!
- Decision effectively made by A.Peacock and Brian Taylor

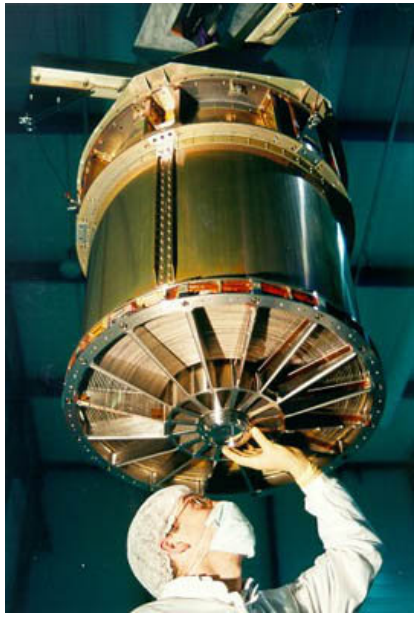
  Under pressure from SWT 1993

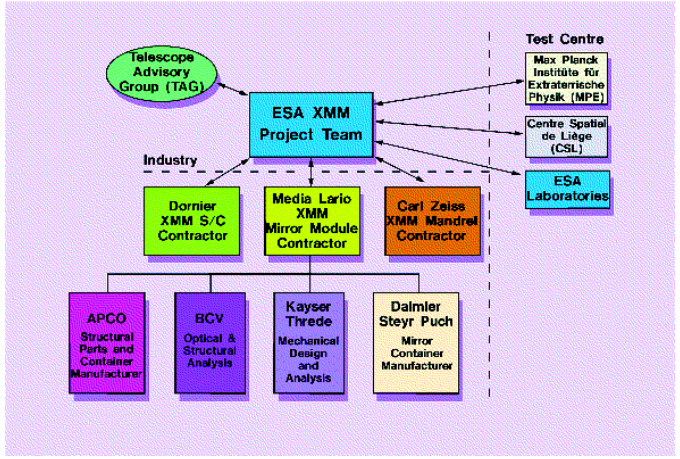
  → R. Lainé + Dsci + DG

New contract with MediaLario, founded 1993, for electroformed Ni (JETX, Beppo-SAX)

start of testing 1995







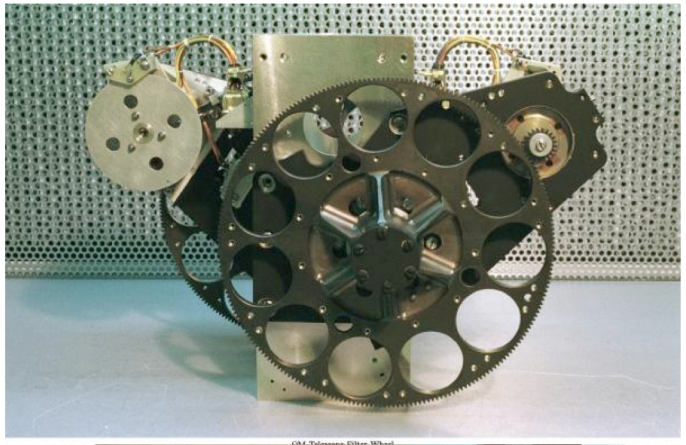
** Aschenbach, B., Citterio, O., Ellwood, J., et al. 1987, The High-Throughput Spectroscopic Mission, Report of the Telescope Working Group, Proc. ESA SP-1084

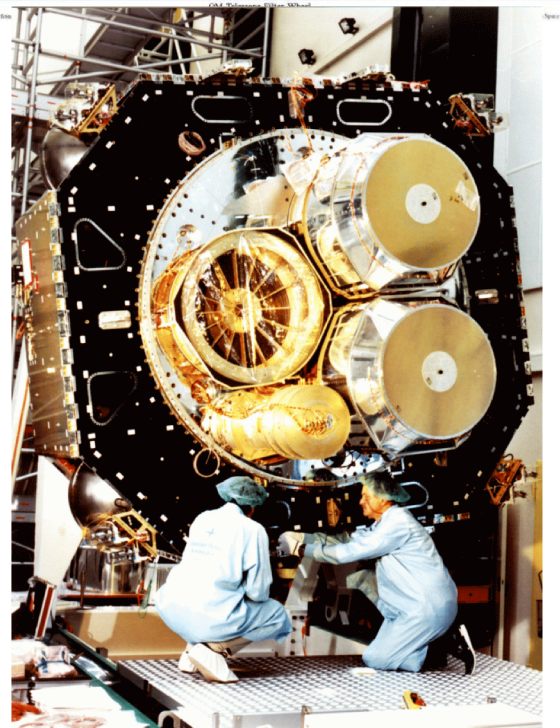
Other Issues Addressed by the Science Working Team

- 1990 – contamination issues, radiation damage, OM mechanical complexity, OM → UV coverage, rather than IR
- Jan 92 – ESTEC project Management changes needed
- 1993 – MOS CCDs for gratings, PN in open position
- 1994 – report on optical IDs of survey sources → Survey Scientist, SSC
- 1996 Stray Light investigation (RFM, from ASCA) – baffle introduced
- 1998 Discussion of contamination and phasing of instrument turn-on

  (this was related to experience with the HST instruments).
- Calibration requirements (science sub-groups)
- Electron deflector located in the exit aperture.
- Also examined the solar-wind proton problem (don't look upwind!)

  reflection of MeV protons
- May 98 – Ground s/w not ready, but EPIC took blame for launch slip





Post-launch ESA Users' group meetings, Villafranca near San Lorenzo de el Escorial
Charoles Restaurant

US users' group meetings
Greenbelt

US Users' Group 2000 -

- Oversight of Guest Observer Facility
- Usefulness of software packages
- Results of GO AO process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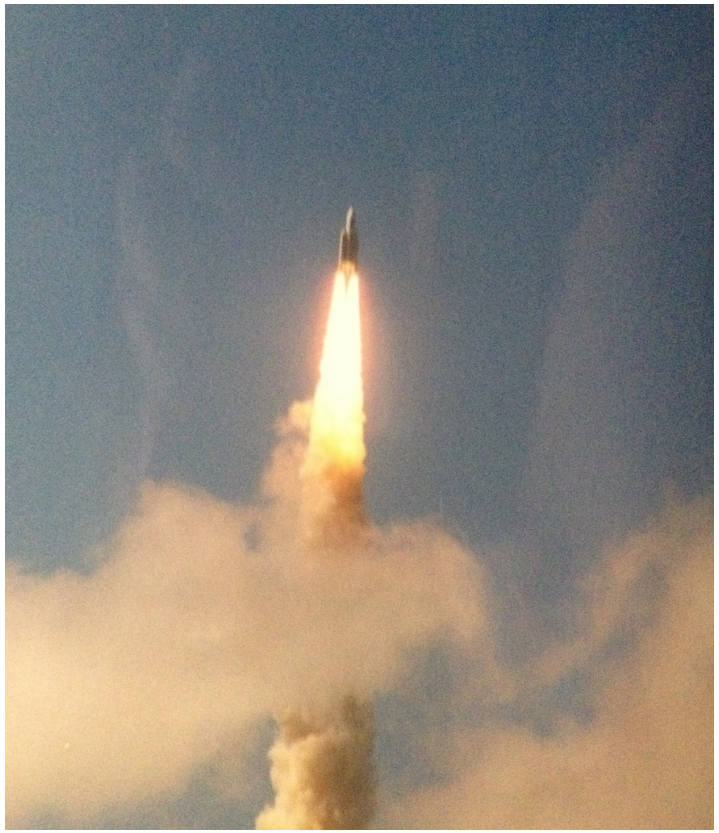


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- Thank you for the invitation!!